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NATIONAL AERONAUTICS  
AND SPACE ADMINISTRATION  
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NASA-16446 (June 2004)  
NASA  
Superseding NASA-16446  
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SECTION 16446

PANELBOARDS  
06/04

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NOTE: Delete, revise, or add to the text in this  
section to cover project requirements. Notes are  
for designer information and will not appear in the  
final project specification.

This section covers power-distribution panelboards  
and lighting and appliance branch-circuit panelboards.

Drawings must indicate the ampere rating of  
panelboards, the number of bus bars, and the voltage  
characteristics of the system to which they are to  
be connected. Frame size, trip rating, number of  
poles, and class of molded-case branch-circuit  
breakers must be indicated. Interrupting rating  
must be shown for power distribution panelboards and  
for lighting and appliance branch-circuit  
panelboards if the latter have an interrupting  
rating of more than 10,000 amperes rms symmetrical.

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PART 1 GENERAL

1.1 REFERENCES

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NOTE: The following references should not be  
manually edited except to add new references.  
References not used in the text will automatically  
be deleted from this section of the project  
specification.  
\*\*\*\*\*

The publications listed below form a part of this section to the extent  
referenced:

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA 416	(1974; R 1981) Filters, Radio Interference
EIA 46	(1987) Test Procedure for Resistance to Soldering (Vapor Phase Technique) for Surface Mount Devices

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2003) Enclosures for Electric Equipment  
(1000 Volts Maximum)

NEMA AB 1 (1999) Molded Case Circuit Breakers and  
Molded Case Switches

NEMA PB 1 (2000) Panelboards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2002) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-HDBK 232 (Rev A) Red/Black Engineering Installation  
Guidelines

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD 595 (1994b) Colors Used in Government  
Procurement

UNDERWRITERS LABORATORIES (UL)

UL 67 (2003) Panelboards

1.2 GENERAL REQUIREMENTS

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**NOTE: If Section 16003 GENERAL ELECTRICAL  
PROVISIONS is not included in the project  
specification, applicable requirements therefrom  
should be inserted and the following paragraph  
deleted.**  
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Section 16003 GENERAL ELECTRICAL PROVISIONS applies to work specified in  
this section.

Detail Drawings shall be submitted for the panelboards consisting of  
fabrication and assembly drawings for all parts of the work in sufficient  
detail to enable the Government to check conformity with the requirements  
of the contract documents. Drawings shall include details of bus layout.

Outline Drawings for panelboards shall indicate overall physical features,  
dimensions, ratings, service requirements, and weights of equipment.

Statements signed by responsible officials of a manufacturer of a product,  
system, or material attesting that the product, system or material meet  
specified requirements. Statements must be dated after the award of this  
contract, name the project, and list the specific requirements which it is  
intended to address.

1.3 SUBMITTALS

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**NOTE: Review submittal description (SD) definitions**  
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in Section 01330 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control. Include a columnar list of appropriate products and tests beneath each submittal description.

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The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES in sufficient detail to show full compliance with the specification:

SD-02 Shop Drawings

Detail Drawings and Outline Drawings shall be submitted for panelboards in accordance with paragraph entitled, "General Requirements," of this section.

SD-03 Product Data

Manufacturer's catalog data shall be submitted for the following items:

Panelboards  
Directory Card and Holder  
Filtered Panelboard

SD-04 Samples

Keys shall then be properly tagged and delivered to the Contracting Officer.

SD-06 Test Reports

Test reports shall be submitted for the following tests in accordance with the paragraph entitled, "Site Testing," of this section. Panelboards shall not be energized until the recorded test data have been submitted to and approved by the Contracting Officer.

Continuity Tests  
Insulation Tests

SD-07 Certificates

Statements shall be submitted in accordance with paragraph entitled, "General Requirements," of this section.

SD-08 Manufacturer's Instructions

Manufacturer's instructions shall be submitted for Panelboards including special provisions required to install equipment components and system packages. Special notices shall detail impedances, hazards and safety precautions.

## PART 2 PRODUCTS

### 2.1 PANELBOARDS

Power-distribution panelboards and lighting and appliance branch-circuit panelboards shall be totally enclosed in a steel cabinet, dead-front circuit breaker type with copper buses, surface- or flush-mounted as indicated. Panelboards shall conform to NEMA PB 1 and NEMA AB 1. Branch circuit panels shall have buses fabricated for bolt-on type circuit breakers.

An outer door or cover, hinged on one side, shall be provided on surface-mounted panelboards to provide gutter space access. A center door shall be provided for circuit breaker/switch access only.

Voltage and current rating, number of phases, and number of wires shall be as indicated. Four-wire distribution panelboards and lighting and appliance branch-circuit panelboards shall be provided with an isolated full-capacity neutral bus. Panelboards shall be rated for [240-volt (maximum), single-phase] [120/208-volt, three-phase] [277/480-volt, three-phase], 60-hertz current.

Three-phase, 4-wire and single-phase, 3-wire distribution lighting and branch circuit panelboards shall be provided with an isolated full-capacity bus providing spaces for single-pole circuit breakers/switches and spaces indicated as spare.

Panelboards shall be provided with a separate grounding bus bonded to the enclosure. Grounding bus shall be a solid bus bar of rectangular cross section equipped with binding screws for the connection of equipment grounding conductors.

Each panelboard, as a complete unit, shall have a short-circuit current rating equal to or greater than the integrated equipment rating shown on the panelboard schedule or as indicated.

Panelboards and main lugs or main breaker shall have current ratings as shown on the panelboard schedule.

Bus bar connections to the branch circuit breakers shall be the "distributed phase" or "phase sequence" type. Single-phase, three-wire panelboard busing shall be such that when any two adjacent single-pole breakers are connected to opposite phases, two-pole breakers can be installed in any location. Three-phase, four-wire busing shall be such that when any three adjacent single-pole breakers are individually connected to each of the three different phases, two- or three-pole breakers can be installed at any location. Current-carrying parts of the bus assembly shall be plated. Mains ratings shall be as shown.

Mechanical lugs furnished with panelboards shall be cast copper or copper alloys of sizes suitable for the conductors indicated to be connected thereto.

[Boxes shall have the manufacturer's standard knockouts and shall be galvanized code-gage sheet steel. Fronts shall be of code-gage sheet steel furnished with hinged doors with adjustable trim clamps for securing the fronts to the boxes.]

[Panelboard box shall be [galvanized] [rust-resistant] code-gage sheet

steel without knockouts. Entire panelboard front shall be hinged on one side with a piano hinge for the full height and shall also have captive screws opposite the hinged side. Where panelboards are installed flush with the walls, the installation details shall be such that the hinged front can be opened without damage to the adjacent wall surfaces. Color of the finished coat of trim and front shall match the adjacent walls except that when the box is installed in electrical closets or equipment rooms, the gray finish as specified will be acceptable.]

Panelboard enclosures shall be NEMA 250, Type 1. Enclosures shall be provided with hinged fronts and corrosion-resistant steel pin-tumbler cylinder locks. Locks shall be keyed alike, and two keys shall be provided for each enclosure.

Panelboards shall be finished with [baked] [fast drying] enamel. Finish color shall be No. 61 gray conforming to FED-STD 595.

## 2.2 CIRCUIT BREAKERS

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**NOTE: Include Section 16286 OVERCURRENT PROTECTIVE  
DEVICES in the project specification or include the  
requirements herein.**  
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Circuit breakers shall be the molded-case type as specified in Section 16286 OVERCURRENT PROTECTIVE DEVICES. Frame and trip ratings shall be as indicated.

Interrupting rating of circuit breakers shall be as indicated. If not shown, the interrupting rating for circuit breakers in [120/208] [\_\_\_\_\_] -volt panelboards shall be not less than [10,000] [\_\_\_\_\_] amperes rms symmetrical, and that for breakers in [277/480] [\_\_\_\_\_] -volt panelboards shall be not less than [25,000] [\_\_\_\_\_] amperes rms symmetrical.

Circuit breakers shall be bolt-on type. Plug-in type shall not be acceptable.

Shunt trips shall be provided where indicated.

In branch circuit panelboards, branch circuit breakers feeding convenience outlets shall have sensitive instantaneous trip settings of not more than [10] [\_\_\_\_\_] times the trip rating of the breaker to prevent repeated arcing shorts resulting from frayed appliance cords. Single-pole 15- and 20-ampere circuit breakers shall be UL listed as "Switching Breakers" at [120 volts ac] [277 volts ac]. UL Class A (5-milliampere sensitivity) ground fault circuit protection shall be provided on 120-volt ac branch circuit as indicated. This protection shall be an integral part of the branch circuit breaker that also provides overload and short-circuit protection for branch circuit wiring. Tripping of a branch circuit breaker containing ground fault circuit interruption shall not disturb the feeder circuit to the panelboard. A single-pole circuit breaker with integral ground fault circuit interruption shall require no more panelboard branch circuit space than a conventional slide pole circuit breaker.

Connections to the bus shall be bolt-on type.

When multiple wires per phase are specified, the circuit breakers shall be furnished with connectors made to accommodate multiple wires.

Circuit breaker spaces called out on the drawings shall be complete with mounting hardware to permit ready installation of the circuit breakers.

### 2.3 DIRECTORY CARD AND HOLDER

A directory card shall be mounted on the inside of hinged fronts and doors [under glass] [0.030-inch 0.76 millimeter thick minimum plastic] in a metal frame, with spaces for circuit numbers, outlets controlled, and room numbers. Where hinged fronts or doors are not required, the directory card shall be provided [under glass] [0.030-inch 0.76 millimeter thick minimum plastic] in a metal frame mounted on the left-hand side of the front trim. Directory card shall identify each branch circuit with its respective and numbered circuit breaker.

### 2.4 FILTERED PANELBOARDS

#### 2.4.1 General

Panelboards shall be designed for the distribution, control, and protection of electrical circuits, providing filtering and shielding performance and, when specified, shall conform to MIL-HDBK 232. (Portions of MIL-HDBK 232 are classified and will be available only on classified projects to approved companies and individuals.)

Panelboard cabinet shall be [12]-gauge [2.7] millimeter [\_\_\_\_\_] steel minimum, with corrosion-resistant finish and four external mounting brackets welded to the case. Front door and trim shall be of code gage steel, with gray finish, equipped with directory, holder, adjustable trim clamps, hinges, self-latching catch, tumbler lock and key and shall bear the UL label. A red diagonal strip shall be provided across the outside surface of door and trim.

#### 2.4.2 RF Shielding

Circuit breaker and filter compartments shall be completely radio-frequency (RF) shielded and shall comply with specified shielding requirements with front door open. Case seams shall be continuous inert gas welded. Removable circuit breaker actuator faceplate and the filter compartment cover shall be fitted with corrosion-resistant RF gasketing material and be installed in place with suitable fasteners having a maximum spacing of [3] inches [75] millimeter [\_\_\_\_\_] on center. RF filter units shall be mounted to the internal shield wall with similar RF gasketing to ensure RF shielding integrity.

#### 2.4.3 Circuit Breaker Actuators

Circuit breaker operating mechanisms shall be designed to maintain rf shielding effectiveness without limit to time or number of operations.

#### 2.4.4 Terminals

Filter terminals shall be of high-temperature alumina ceramic, continuously brazed to filter case. Soft solder shall not be used. Ceramic terminal shall incorporate a permanently attached flexible lead, with a suitable electric lug. Incoming service connections shall be made to the filter lead at a UL-approved, flame-retardant standoff insulator, mounted in the filter compartment.

#### 2.4.5 Attenuation

Each filter unit shall provide a minimum insertion loss of [100] [\_\_\_\_\_]dB over the frequency range of [14 kilohertz (kHz) to 10 gigahertz (GHz)] [\_\_\_\_\_] . Full rated load insertion loss of [100] [\_\_\_\_\_]dB in the frequency range [14 kHz to 20 megahertz (MHz)], to [14] [\_\_\_\_\_]kHz shall be measured by a Government-approved laboratory.

#### 2.4.6 Current

Each filter unit shall be capable of carrying its full rated current continuously without heat rise exceeding [122 degrees F/50 degrees C] [\_\_\_\_\_] above ambient temperature. Each filter shall be capable of withstanding a [100] [\_\_\_\_\_] -percent overload for [30] [\_\_\_\_\_] seconds without damage.

#### 2.4.7 Voltage

Each filter unit shall be capable of continuous operation at its full rated voltage and withstanding an initial voltage test of twice its rated voltage without damage.

#### 2.4.8 Circuit Breakers

Circuit breakers shall be rated minimum 10,000 amperes asymmetrical ac interrupting capacity, 5,000 amperes dc, and shall be in accordance with NEMA AB 1.

#### 2.4.9 RF Filters

RF filter units shall be designed to suppress and reduce the amplitude of undesired rf energy conducted by power service lines. Rf filter units shall be designed in compliance with the applicable requirements of EIA 416.

Filter cases shall be made of steel, [16]-gage 1.6 millimeter [\_\_\_\_\_] minimum, corrosion-resistant finish with a blue lacquer over zinc chromate primer. Conductive grounding surfaces shall be either plated or made of corrosion-resistant steel. Hermetic seams shall be continuous inert gas welded; no soft solder shall be used. Internal components shall be firmly mounted to withstand applicable shock and vibration test requirements without damage.

Fluid impregnant shall conform to UL nonflammable classification. Internal components shall be fully impregnated and intimately immersed in the fluid to obtain the full benefit of cooling by convection flow through the liquid medium to filter case. Filter case shall be completely filled with the fluid impregnant.

#### 2.4.10 Filter Discharge Unit

A filter discharge unit for three-filtered circuits shall be installed on the panelboard. Unit shall meet applicable requirements of EIA 46, and shall be installed in accordance with NFPA 70.

### 2.5 FACTORY TESTING

Complete panelboards shall be tested in accordance with UL 67.



## 2.6 PRECAUTIONARY LABEL

To ensure persons are aware of immediate or potential hazard in the application, installation, use, or maintenance of panelboards, each panelboard shall be conspicuously marked on the trim or dead front shield with the text (or equivalent) **DANGER** symbol. If the panel is supplied with a door, the label shall be visible when the door is in the open position.

## PART 3 EXECUTION

### 3.1 INSTALLATION

Panelboards shall be installed as indicated and in accordance with the manufacturer's instructions. Panels shall be fully aligned and mounted so that the height of the top operating handle will not exceed [72]-inches 1800 millimeter [\_\_\_\_\_] above the finished floor.

Directory-card information shall be typewritten in capital letters to indicate outlets controlled and final room numbers served by each circuit and shall be mounted in holders behind protective covering.

### 3.2 SITE TESTING

Each panelboard enclosure key shall be shown to operate the enclosure locks in the presence of the Contracting Officer.

Panelboards shall be given continuity and insulation tests after the installation has been completed and before the panelboard is energized.

Test equipment, labor, and personnel shall be provided by the Contractor as required to perform the tests as specified. Continuity tests shall be conducted using a dc device with [bell] [buzzer] [\_\_\_\_\_].

Insulation tests on 480-volt panelboards shall be conducted using a 1,000-volt insulation-resistance test set. Readings shall be recorded every minute until three equal and consecutive readings have been obtained. Resistance between phase conductors and between phase conductors and ground shall be not less than 50 megohms.

Insulation tests on panelboards rated 300 volts or less shall be conducted using a 500-volt minimum insulation-resistance test set. Readings shall be recorded after 1 minute and until the reading is constant for 15 seconds. Resistance between phase conductors and between phase conductors and ground shall be not less than 25 megohms.

Test data shall be recorded and shall include the location and identification of panelboards and megohm readings versus time.

-- End of Section --